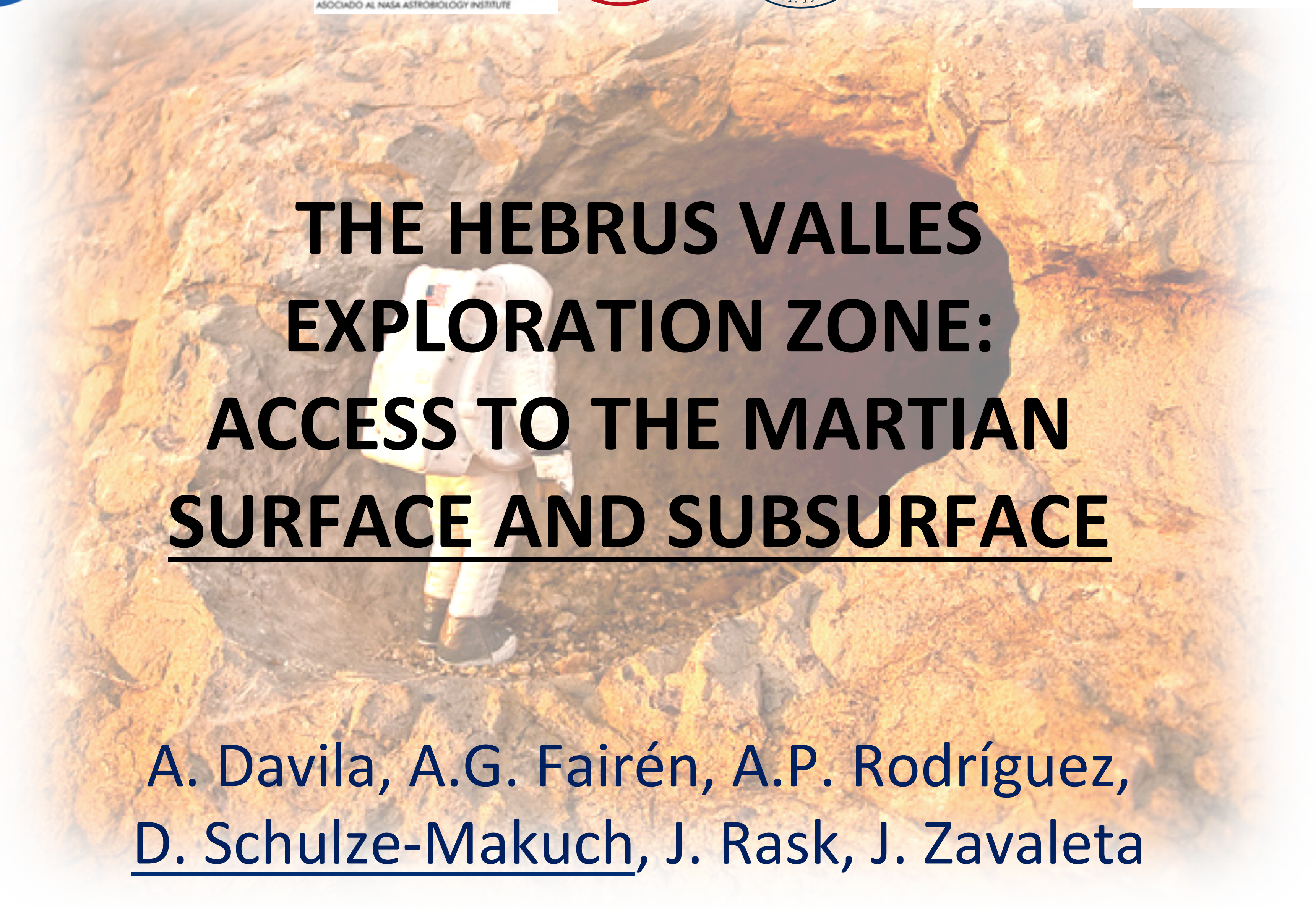
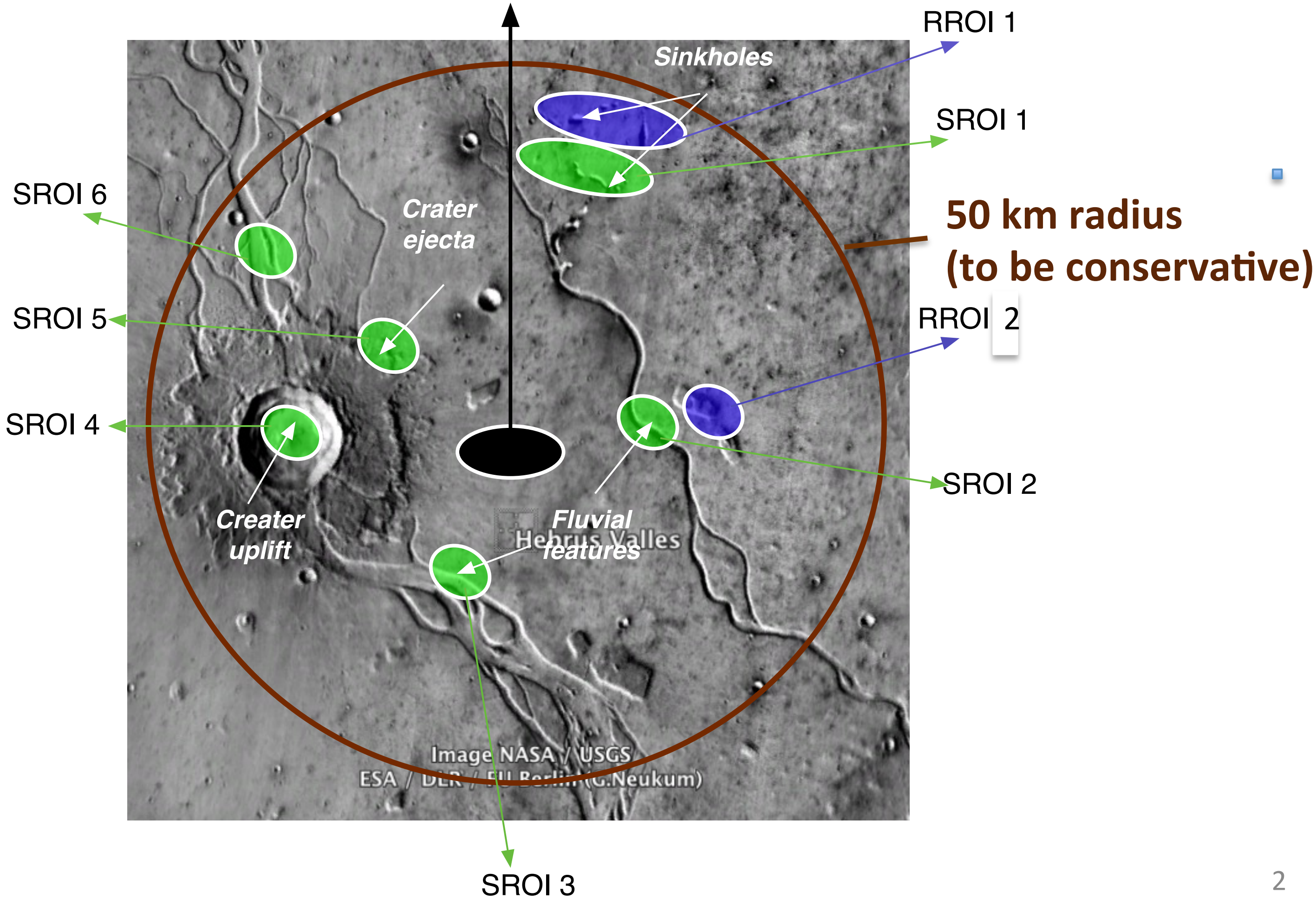


THE HEBRUS VALLES EXPLORATION ZONE: ACCESS TO THE MARTIAN SURFACE AND SUBSURFACE

A. Davila, A.G. Fairén, A.P. Rodríguez, D. Schulze-Makuch, J. Rask, J. Zavaleta

Exploration Zone Map

Mars landing site and surface field station
20°05’ N, 126°38’ E / Elevation = -3600 m



Science ROI(s) Rubric

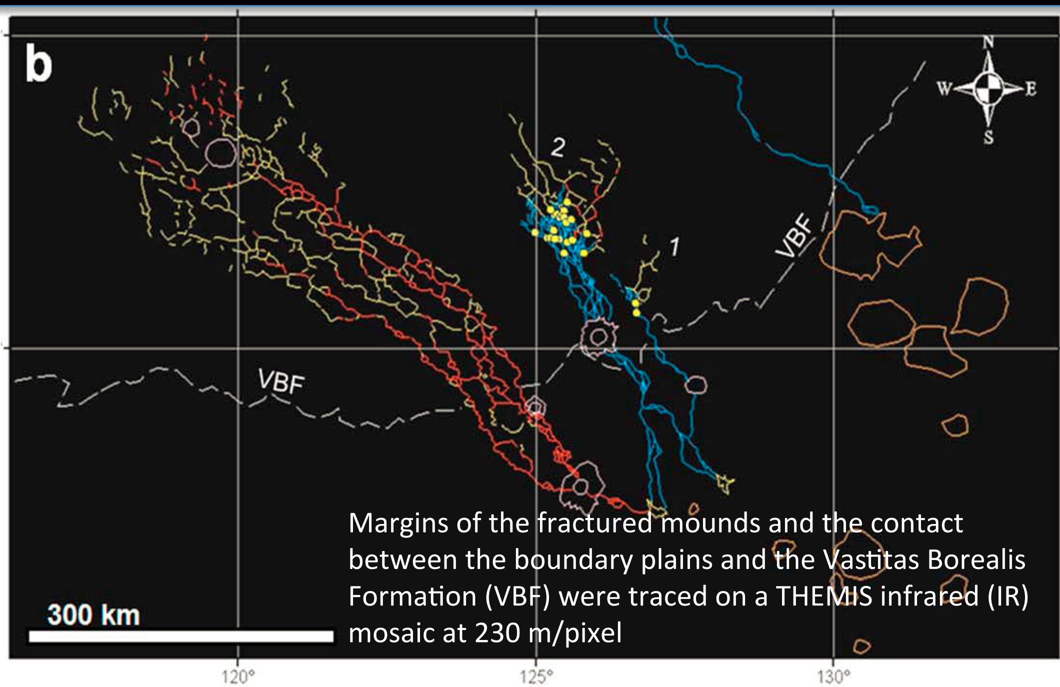
			Site Factors	SROI1	SROI2	SROI3	SROI4	SROI5	SROI6	RROI1	RROI2	EZ SUM
Science Site Criteria	Astrobio	Threshold (AND/OR)	**Potential for past habitability**	●	●	●	●		●			5
			Potential for present habitability/refugia	●						●		1
		Qualifying	Potential for organic matter, w/ surface exposure	●	●	●			●			4
	Atmospheric Science	Threshold	**Noachian/Hesperian rocks w/ trapped atmospheric gases**	●	●	●	●	●	●			6
		Qualifying	Meteorological diversity in space and time	○	○	○	○	○	○			6
			High likelihood of surface-atmosphere exchange	?	?	?	?	?	?			
			Amazonian subsurface or high-latitude ice or sediment	○								1
			High likelihood of active trace gas sources	?	?	?	?	?	?			
	Geoscience	Threshold	**Range of martian geologic time; datable surfaces**	●	●	●	●	●	●			6
			Evidence of aqueous processes	●	●	●	●	●	●			6
			Potential for interpreting relative ages	●	●	●	●	●	●			6
		Qualifying	Igneous Rocks tied to 1+ provinces or different times									
			Near-surface ice, glacial or permafrost		○		○		○	○		4
			Noachian or pre-Noachian bedrock units									
			Outcrops with remnant magnetization									
			Primary, secondary, and basin-forming impact deposits				●	●				2
			Structural features with regional or global context									
			Diversity of aeolian sediments and/or landforms	?	?	?	?	?	?			

Key	
●	Yes
○	Partial Support or Debated
	No
?	Indeterminate

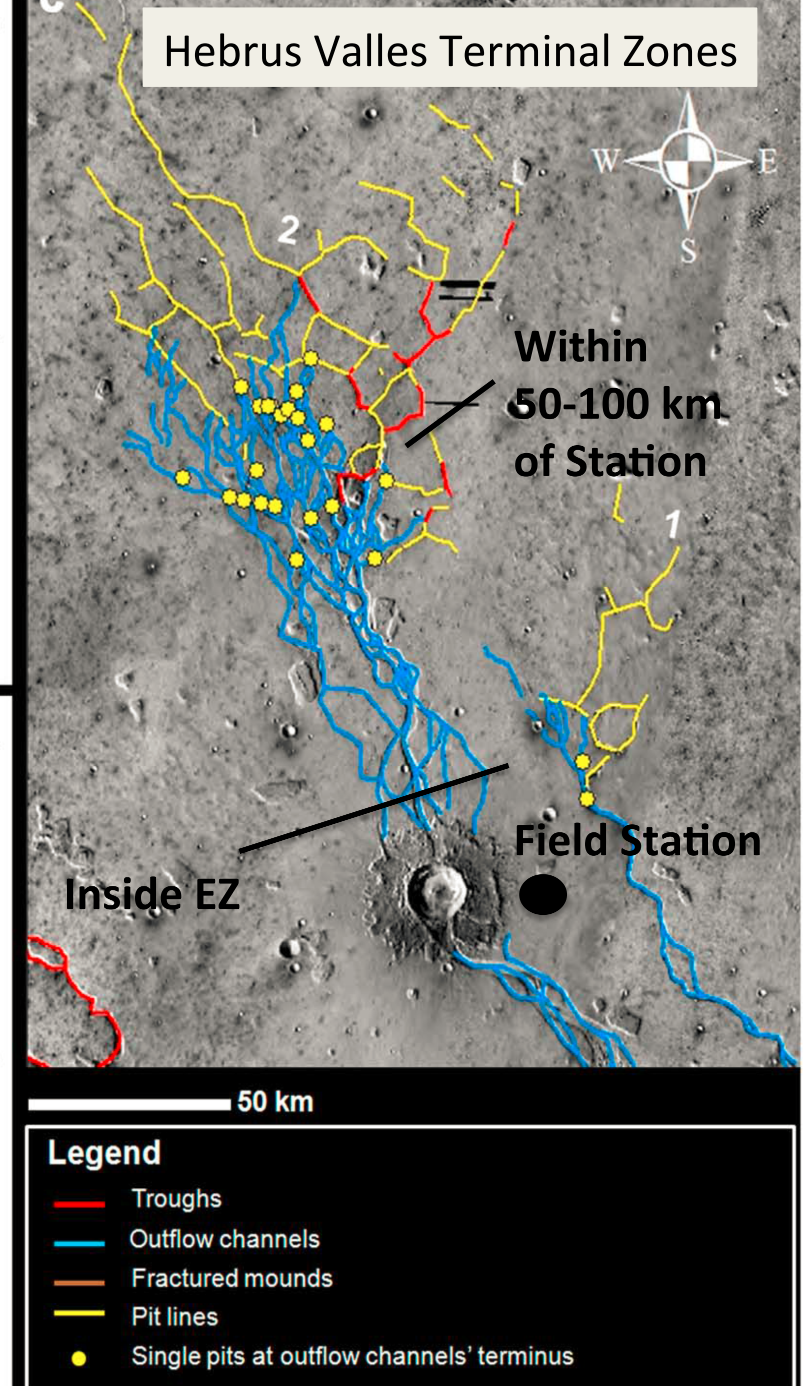
Each of the two distributaries terminates within isolated pit and trough networks suggesting drainage of floodwaters into the subsurface

The absence of evidence for ponding upstream of pits and troughs and the presence of channel pendant bars that extend into troughs are indicative of rapid and unobstructed flow into the subsurface similar to sinkholes on Earth

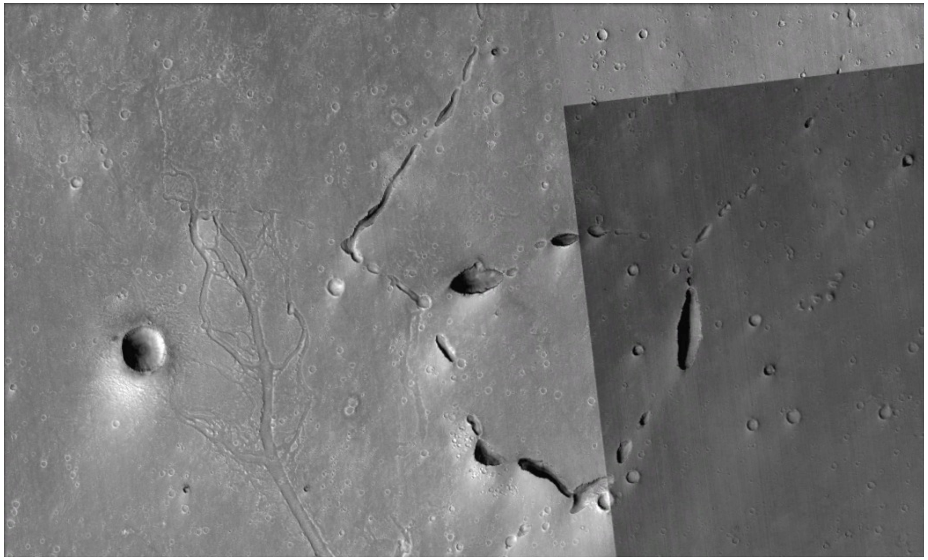
(Rodriguez et al., 2012)



Margins of the fractured mounds and the contact between the boundary plains and the Vastitas Borealis Formation (VBF) were traced on a THEMIS infrared (IR) mosaic at 230 m/pixel



Science ROI 1



- N20º 46’ 17”/ E126º 47’ 46”
- Elevation = -3680m
- Multiple-point access to the subsurface with a high preservation potential for evidence of past habitability and biosignatures.

Science ROI 1 (continued)

- Rodriguez et al. (2012) suggested high hydraulic pressure associated with mud volcanism forming pseudo-karstic erosion a long feeder conduits
- Carr and Malin (2000), on the other hand, suggested a subsurface karst landscape by dissolution of buried carbonates
- **Either way:** The inferred magnitude of floodwater infiltraon points to the existence of structurally stable caverns with permafrost having a mechanical strength of limestone at the average temperatures at Hebrus Valles
- Since Martian gravity is 0.38 g, it allow for caves that are 2.5 x larger than Earth- equivalents (and up to 6 km deep)

Where should we look for Life ?

Cave Environments

Secondary mineral formations (speleothems)

Permanent or transient ices

(by P. Boston, 2003)

New Mexico, Earth

Cueva de Villa Luz, Earth

Mars?

Photo by K. Ingham

LOTS of fish…

Photo by Steve Alvarez

In situ microbially mediated mineral formation ?

Investigation of a potential long-term stable habitat

Preservation of potential biosignatures in caves

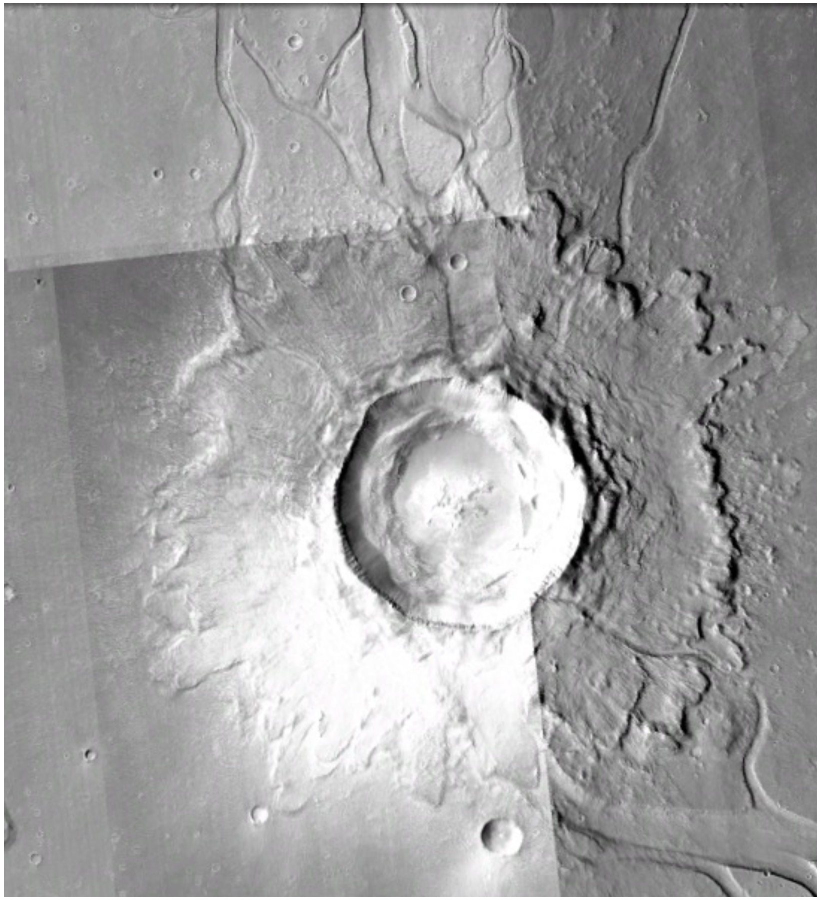
Science ROI 2

- N19º 46' 37" / E126º31'49"
- Elevation = -3641
- Fluvial features indicative of aqueous processes and potential habitability

Science ROI 3

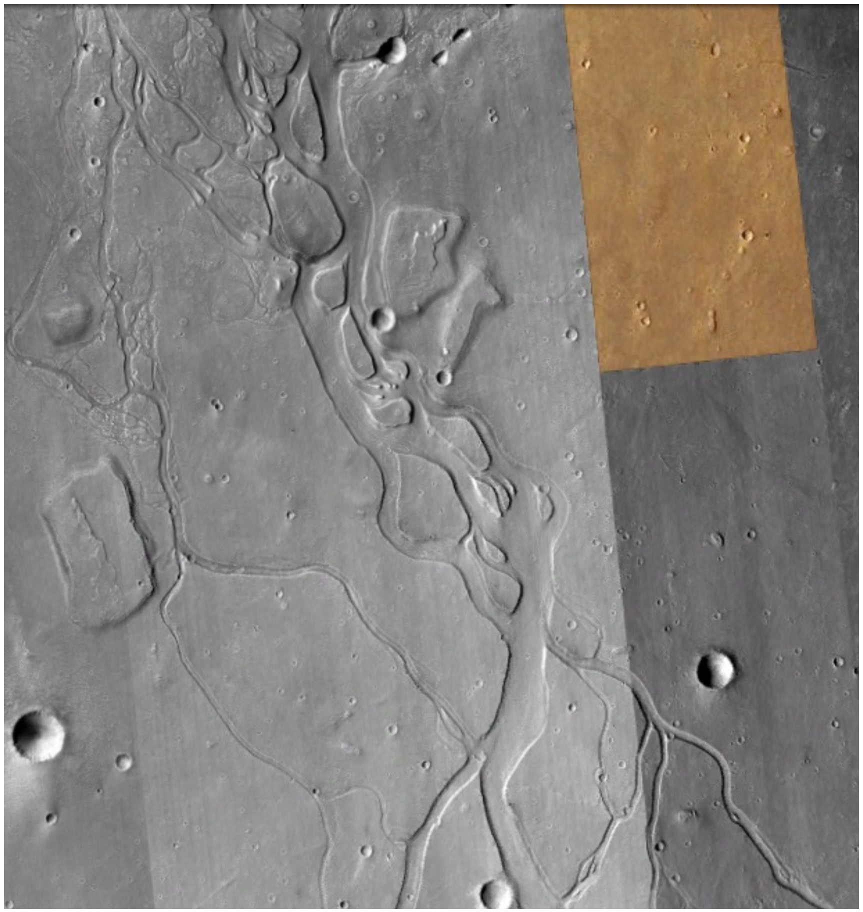
- N19º 44’ 69” / E126º 31 ’ 39”
- Elevation = é   3695
- Fluvial features indicative of aqueous processes and potential habitability

Science ROI 4&5



- N20º 06’ 30” / E126º 03 ’ 59”
- Elevation = -3913
- Access to Hesperian subsurface materials:
  - Trapped gases
  - Dating geologic units
  - Interpreting relative ages
  - Primary and secondary impacts

Science ROI 6



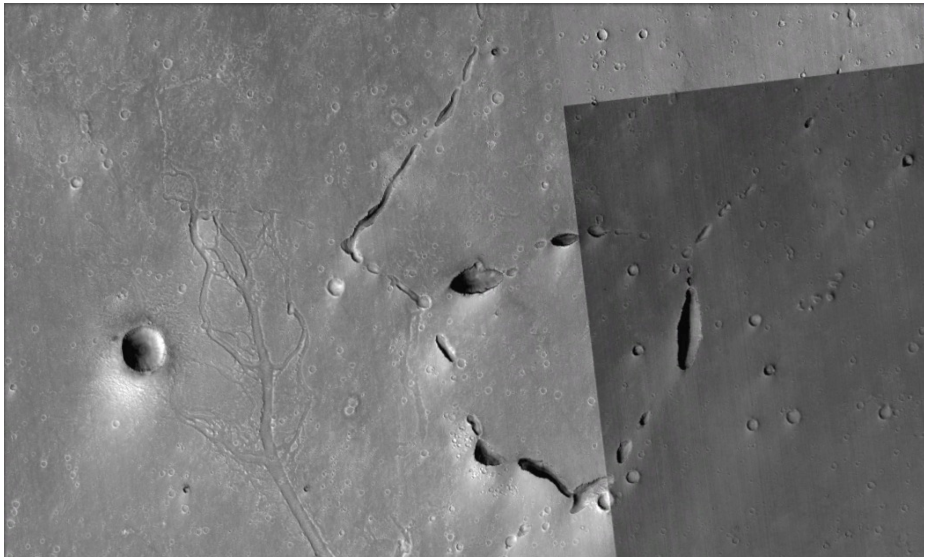
- N21º 01’ 29” / E125º 54 ’ 52”
- Elevation = -3774
- Fluvial features indicative of aqueous processes and potential habitability

Resource ROI(s) Rubric

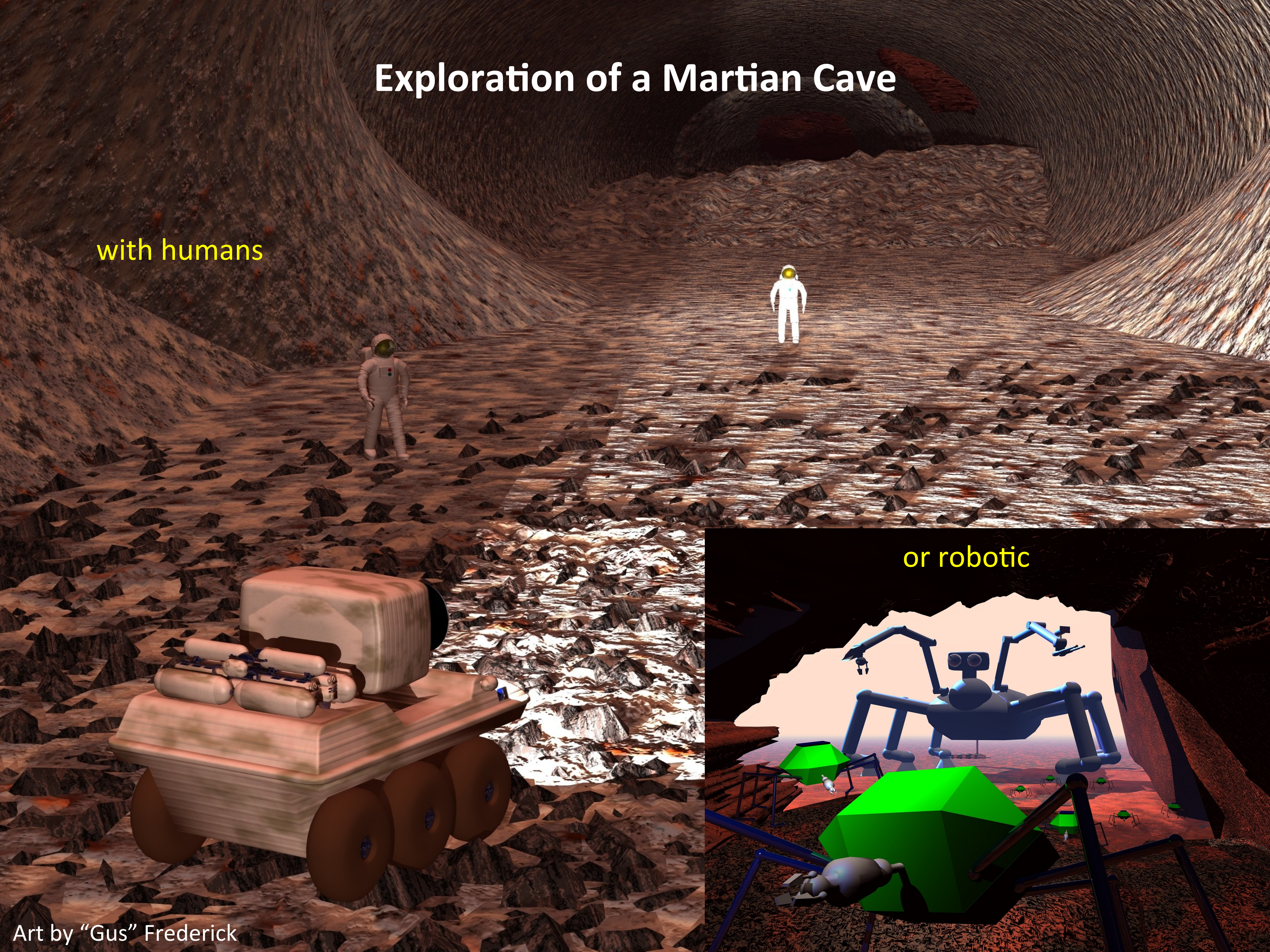
Criteria	Group	Level	Site Factors	SROI1	SROI2	SROI3	SROI4	SROI5	SROI6	RROI1	RROI2	EZ SIM
ISRU and Civil Engineering Criteria	Engineering		Meets First Order Criteria (Latitude, Elevation, Thermal Inertia)	●	●	●	●	●	●	●	●	
	Water Resource	Threshold	AND/OR: **Potential for ice or ice/regolith mix**	●	●	●			●	●		
			AND/OR: **Potential for hydrated minerals**		●	●	●		●			
			Quantity for substantial production		○	○			○	○		
			Potential to be minable by highly automated systems		●	●			●	●		
			Located less than 3 km from processing equipment site									
			Located no more than 3 meters below the surface									
			Accessible by automated systems									
		Qualifying	Potential for multiple sources of ice, ice/regolith mix **and** hydrated minerals		●	●			●	●		
			Distance to resource location can be >5 km		●	●			●	●		
			Route to resource location must be (plausibly) traversable		●	●			●	●		
	Civil Engineering	Threshold	**~50 sq km region of flat and stable terrain with sparse rock distribution**	**Multiple sites**								
			1–10 km length scale: <10°	**Multiple sites**								
			Located within 5 km of landing site location	**Multiple sites**								
		Qualifying	Located in the northern hemisphere	●	●	●	●	●	●	●	●	
			Evidence of abundant cobble sized or smaller rocks and bulk, loose regolith	●	●	●	●	●	●	●	●	
			Utilitarian terrain features	●	●	●	●	●	●	●	●	
	Food Production	Qualifying	Low latitude	●	●	●	●	●	●	●	●	
			No local terrain feature(s) that could shadow light collection facilities	●	●	●	●	●	●	●	●	
			Access to water	○	○	○	○	○	○	○	○	
			Access to dark, minimally altered basaltic sands	○	○	○	○	○	○	○	○	
	Metal/Silicon Resource	Threshold	**Potential for metal/silicon**	●	●	●	●	●	●	●	●	
			Potential to be minable by highly automated systems	●	●	●	●	●	●	●	●	
			Located less than 3 km from processing equipment site	●	●	●	●	●	●	●	●	
			Located no more than 3 meters below the surface	●	●	●	●	●	●	●	●	
			Accessible by automated systems	●	●	●	●	●	●	●	●	
		Qualifying	Potential for multiple sources of metals/silicon	○	○	○	○	○	○	○	○	
			Distance to resource location can be >5 km	○	○	○	○	○	○	○	○	
			Route to resource location must be (plausibly) traversable	○	○	○	○	○	○	○	○	

Key	
●	**Yes**
○	**Partial Support or Debated**
	No
?	**Indeterminate**

Resource ROI 1



- N20º 46’ 17”/ E126º 47’ 46”
- Elevation = -3680m
- Multiple-point access to the subsurface:
  - High potential for water
  - Shelter


Exploration of a Martian Cave
with humans
or robotic
Art by “Gus” Frederick


Possible Discovery of a Lake within a Martian Cave
Cave Advantages as a Resource:
• Protection from Radiation Environment
• Constant temperatures maintained by internal heat
• Higher amounts of water vapor may allow liquid water to persist
Art by "Gus" Frederick

A Vision of a Human Settlement on Mars

Hillside Development, a permanent settlement design by the Mars Foundation

Resource ROI 2

- N20º 12’ 07”/ E127º 03’ 04”
- Elevation = -3680m
- Flat and stable terrain near the LS. Slopes <5º over most of the EZ.
- Access to silicate materials over the entire EZ, including sediments
- Low latitude, plenty of sunlight
- Access to surface shelter

EZ Data Needs

- The single most important additional data set needed to assess the science potential of the EZ would be high-resolution mapping of the terrain and its composition (MRO-HiRISE and CRISM, MEx-OMEGA, or similar). This is the highest priority because it would be necessary a previous good understanding of landforms and surface composition to ensure high-quality science return.
- The single most important additional data set needed to assess the resource potential of the EZ would be probing the subsurface using radr measurements with high depth resolution (MRO-SHARAD or similar). This is the highest priority because a previous good knowledge of the actual extension and geometry of the subsurface caverns available for habitation would be required.

First Permanent Human Habitation on Earth: Caves

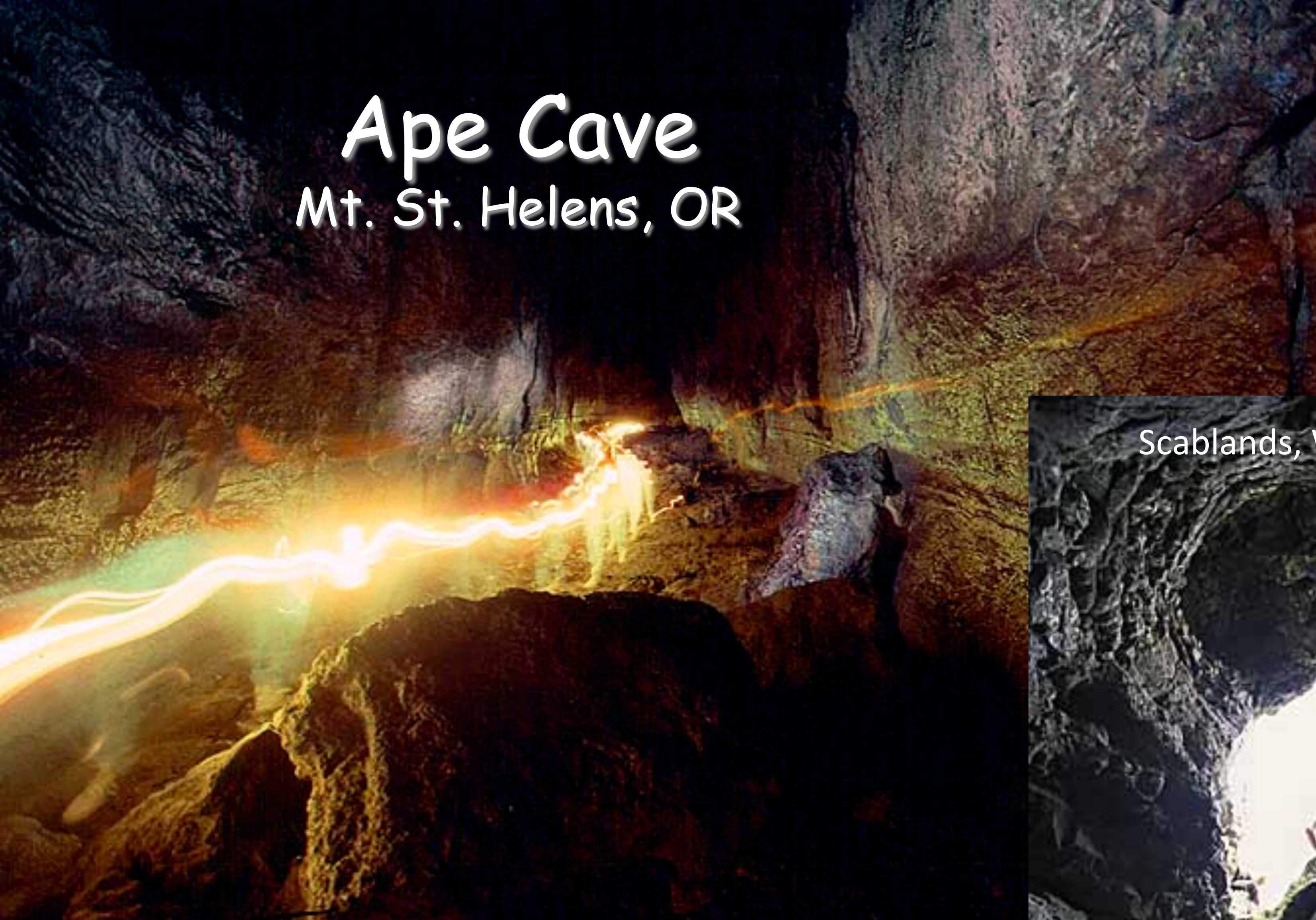
https//www.temehu.com/tashwinat.

A Human Field Station should utilize this great resource on Mars

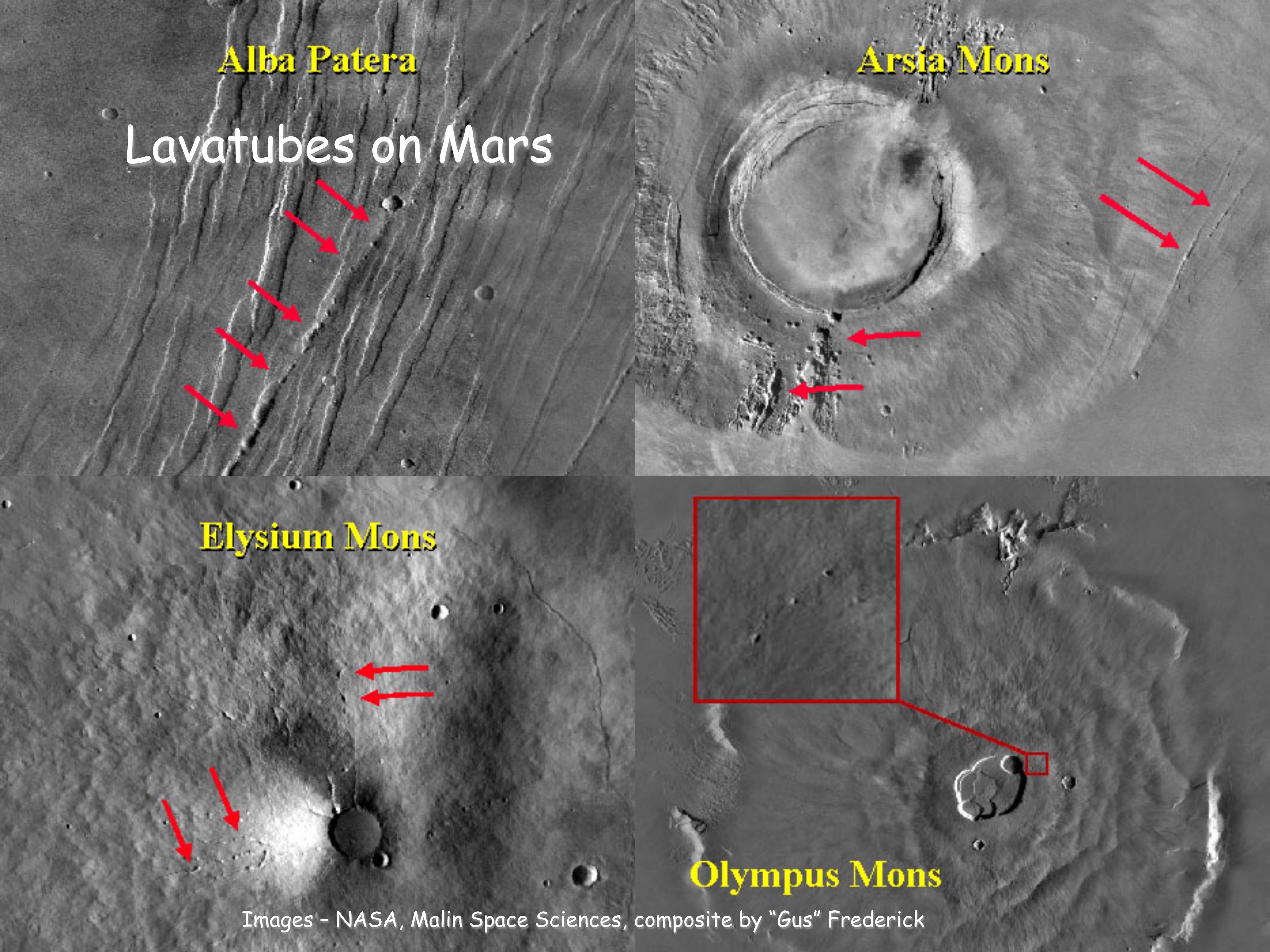
BACKUP SLIDES

Prioritization List of EZ Data Needs

- Prioritized list of orbiter/rover data to be collected to assess the science potential of the EZ:
  1. High-resolution imagery (HiRISE-like) to characterize terrains for rover traverses and EVAs.
  2. Compositional data (CRISM and OMEGA-like) to prepare for in situ analyses.
  3. Mineralogical data (THEMIS-like) to understand mineral distribution before human exploration.
- Prioritized list of orbiter/rover data to be collected to assess the resource potential of the EZ:
  1. Subsurface radar data (SHARAD-like) to understand the extent and geometry of the subsurface conduits.
  2. Compositional data (CRISM and OMEGA-like) to characterize the availability of resources (ice/water, clays, perchlorates).
  3. THEMIS-like to search for and identify thermal hotspots in the subsurface.



https//www.washington-stae-magazine.wsu.edu/stories/04-fall/scablands/index.htm


Lavatubes on Mars
Alba Patera
Arsia Mons
Elysium Mons
Olympus Mons
Images – NASA, Malin Space Sciences, composite by "Gus" Frederick